
ATIEC 2021
Analytics for Better Decision-Making Using SWIM
EUROCONTROL
Smart.
Secure.
Shareable.
Aviation Information.
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Boeing Global Services

Analytics for better decision-making using SWIM

Overview

- Starting from first principles: objectives of aviation
- Levels of autonomy: supporting humans making decisions
- The current state: availability and challenges of data
- Converting data to decisions with analytics
  - Selecting data – machine learning to resolve discrepancies and fill in gaps
  - Building confidence – explainable AI
  - User-sensitive insights – the same data, different use cases, different advice
  - Increasing optimality while maintaining robustness
- Our recommendations to data providers

Objectives of Aviation

Most aircraft operations (airline, business aviation, military, and some personal aviation) have the goal of **delivering payload**, not moving aircraft

Objectives and Challenges for Aviation

- Payload delivery is aviation's contribution to both the global economy and society
- Payload delivery makes it worth burning fuel
- Payload delivery puts a premium on both efficiency and robustness
  - Passengers
  - Industrial goods
  - Consumer goods
  - Humanitarian goods

- **Recommendation:** when considering efficiency and robustness, think in terms of payload, not aircraft
  - Multiple aircraft and resources
  - Multiple stakeholders
  - The trade-off between robustness and efficiency

Objectives and Challenges for Aviation

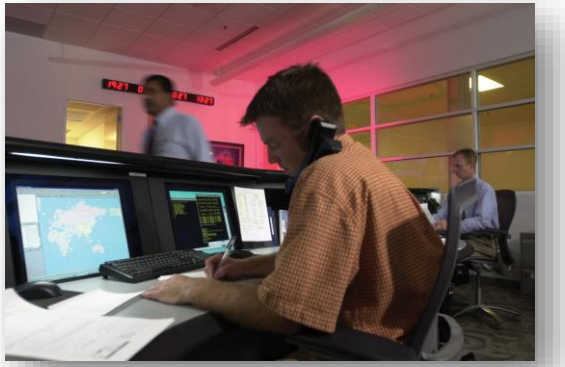
- External factors make demands on efficiency and robustness
  - Sustainability
  - Unpredictable impacts on demand, resources, and operational constraints (e.g., COVID-19)
  - Dynamic humanitarian demands (natural and political)
- **Flexibility** helps balance efficiency and robustness in the face of unpredictability

One promise of SWIM is to enable flexibility, to allow better efficiency without sacrificing robustness:

> "We wait for the first bolt of lightning or the first snowflake to hit before we act" – Delta Air Lines, at 2017 ICAO Global Air Navigation Industry Symposium, talking about the benefits of SWIM

Stakeholders involved in moving payload

Ops Center



Operations Managers

Flight Planners

Operations Controllers

Maintenance Controllers

Crew Controllers

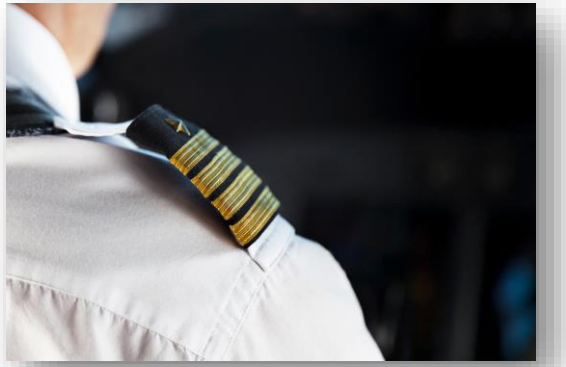
Payload Controllers

Gate

Agents

Passengers

Crew



Pilots

Flight Attendants

Ramp

Ramp Staff
(coordinate baggage, cargo, fuel, catering and duty-free)

Supporting Human Decision-Making

Levels of autonomy

Information Acquisition	Information Analysis	Decision & Action Selection	Action Implementation

Level	Description
1	**No assistance** (human initiates all decisions / actions)
2	**Complete set** of decision / action alternatives
3	**Filtered set** of decision / action alternatives
4	**Single suggested** decision / action
5	Execution of singular decision / action **with approval**
6	Execution of decision / action (**unless vetoed** within a specified time limit)
7	Execution of decision / action (informs **when necessary**)
8	Execution of decision / action (informs **when asked**)
9	Execution of decision / action (informs **when directed** by automation)
10	**Completely autonomous** execution of decision / action (human out of the loop)

Current and near-future air and ATM

Future state UAS/RCO air and ATM

Sheridan & Verplank (1978)

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Current and near-future air and ATM

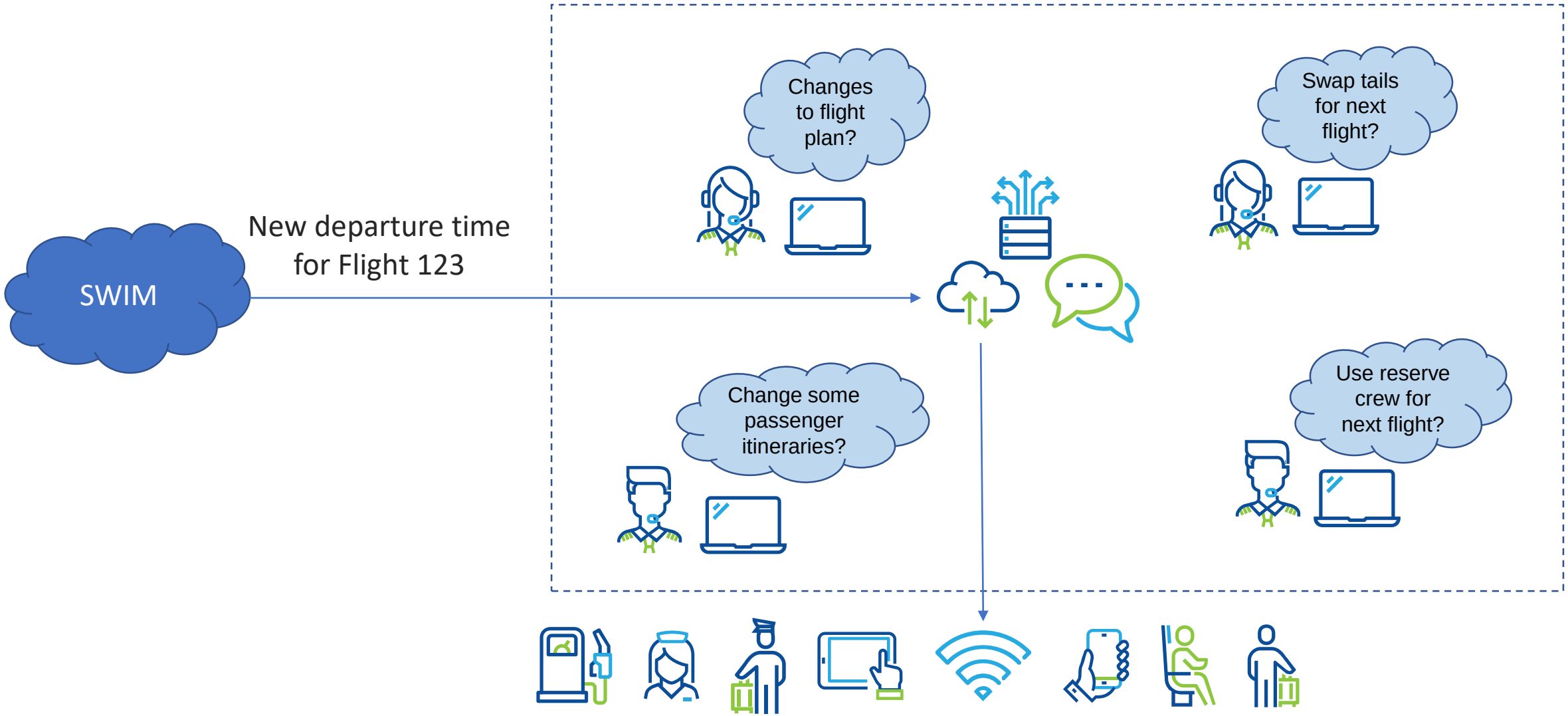
Future-state strategic support

Future state UAS/RCO air and ATM

Sheridan & Verplank (1978)

Supporting Human Decision-Making

Diverse teams working together



Stakeholders involved in moving payload

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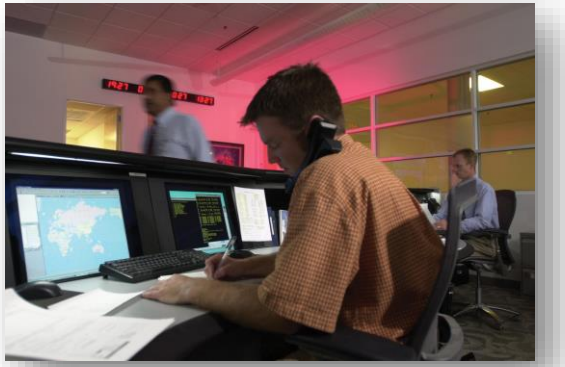

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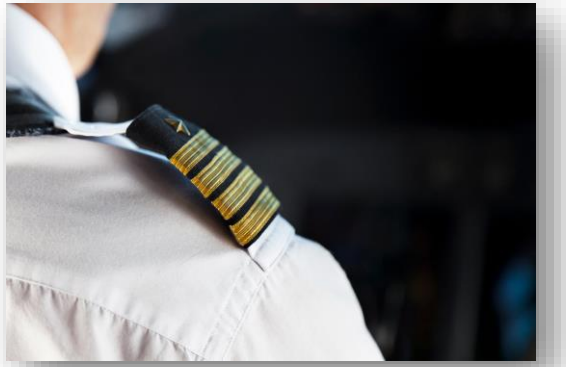

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If a new takeoff time is published via SWIM, all of these stakeholders might be impacted – not just for this flight, for others also. But if we just send them the time, they won't know its relevance to them.

Availability and challenges of data

now

future

Petabytes of electronic data and information generated from airline operations.

~ 1 TB / Flight

data

data

data

Availability and challenges of data

- NOTAMs are one relevant example, and instances of data proliferation are abundant – and increasing at a high rate.
- Solutions that claim to enhance situational awareness are often primarily focused on data delivery.
- Access to data supports **perception** – but this is only one of three necessary components of situational awareness.

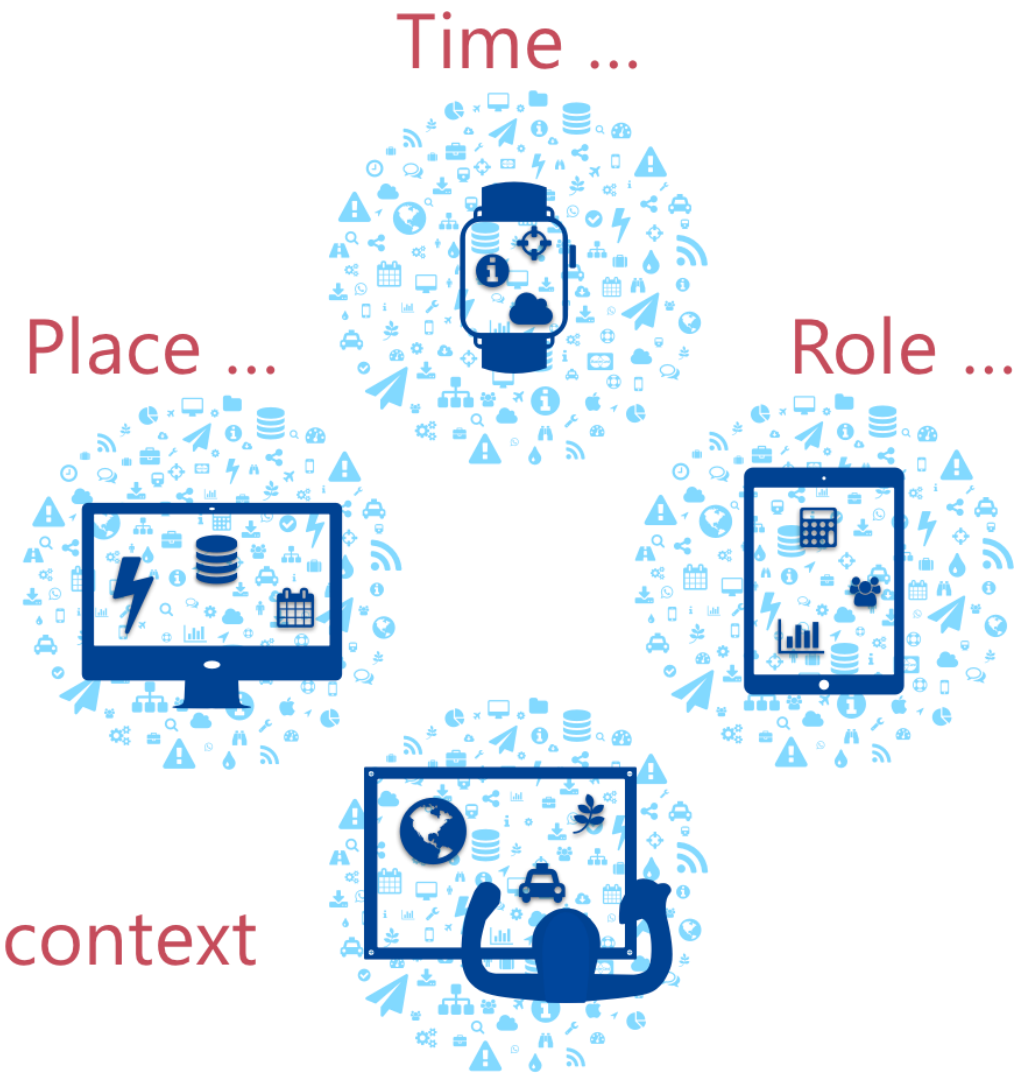
Global NOTAM Proliferation

Region	14 year Increase
Africa (D, F, G, H)	217%
Asia (R, V, W, Z)	293%
Asia (Mid) (O)	251%
Europe (L, E, B)	254%
North America (C, K, P)	703%
Pacific (A, N, Y)	249%
Russia / Central Asia (U)	927%
South / Central America (M, S, T)	215%
Total	**383%**

ICAO IMP (2015)

Availability and challenges of data

- In a data-rich environment, unfiltered data leads to cognitive overload and sub-optimal decisions.
- More precise data enhances context — **comprehension** is often a function of the data not presented.
- Similarly, precisely targeted analytics enhance the user's ability to **project** system state.



... the value of data is in its context

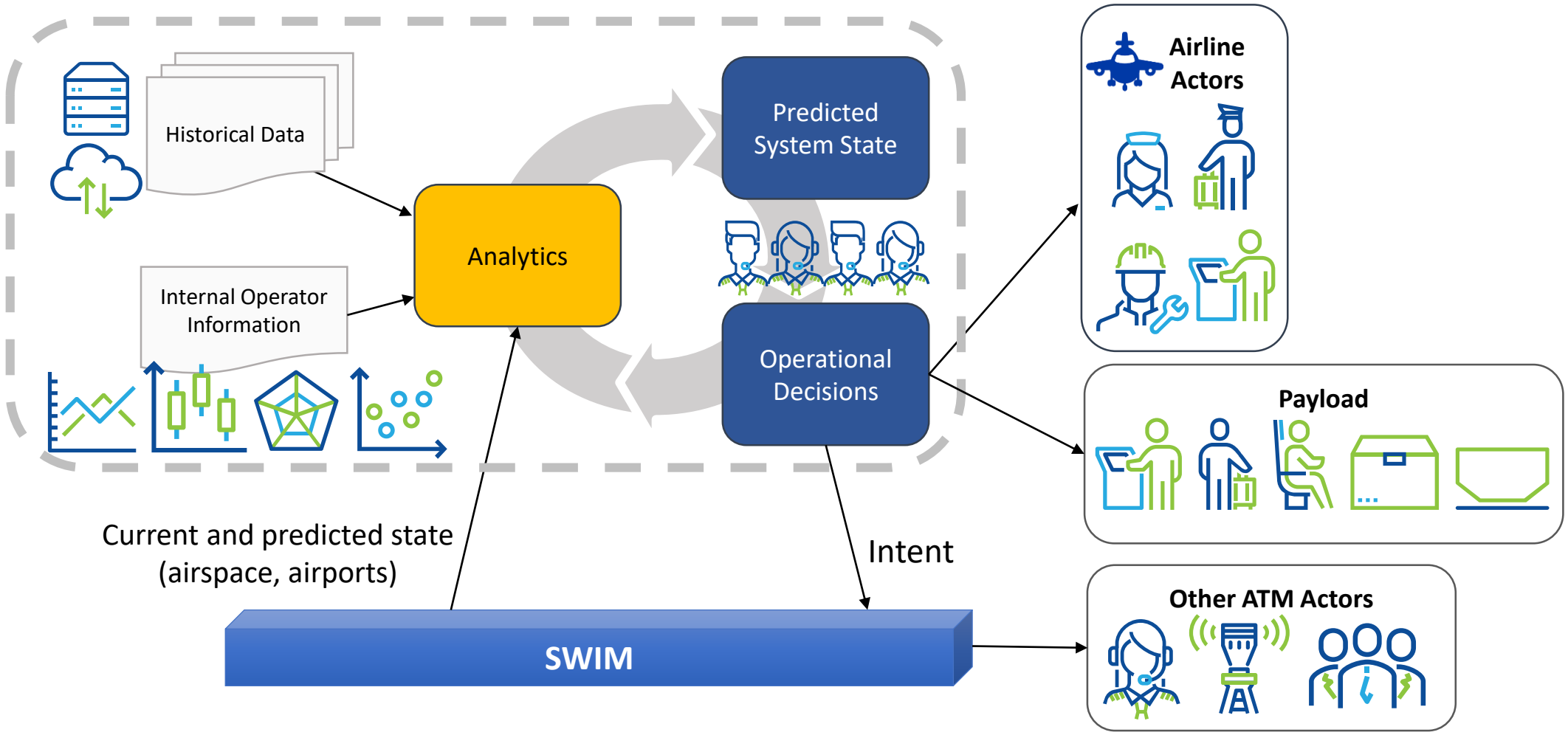
Availability and challenges of data

Some **Frequently-Asked Questions** when we talk about SWIM:

- How do you deal with flying across different regions – some don't have SWIM at all, and the ones that do don't all match?
- Do users trust what analytics tells them to do?
- With all that data being published, isn't the user just overwhelmed?
- Can the availability of real-time data make planning better?

These are all valid concerns. Analytics helps mitigate the problems and unlock SWIM's value.

Converting Data to Decisions with Analytics

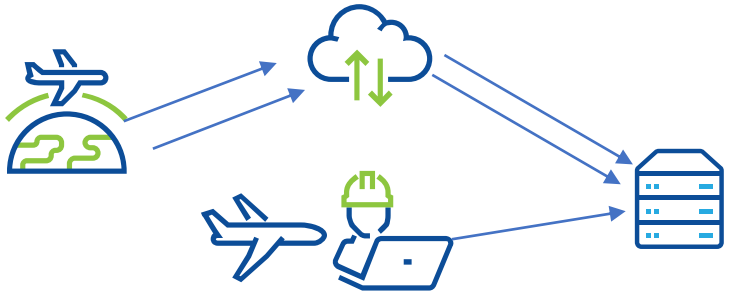


Converting Data to Decisions with Analytics

FAQ: How do you deal with flying to different regions – some don't have SWIM at all, and the ones that do don't all publish consistent information?

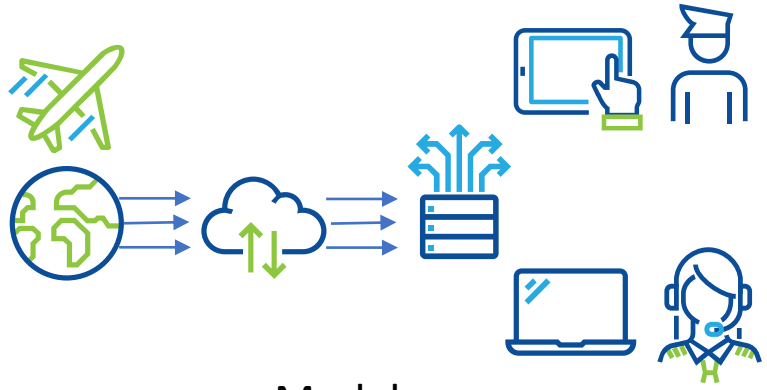
Analytics Solution: Machine Learning

- Collect data published by different regions for a flight
- Collect truth data from the aircraft
- Train a model to select, blend, and project when there are inconsistent and missing data
- Use the model to predict and project data for flights through multiple regions



Data collection

Model training



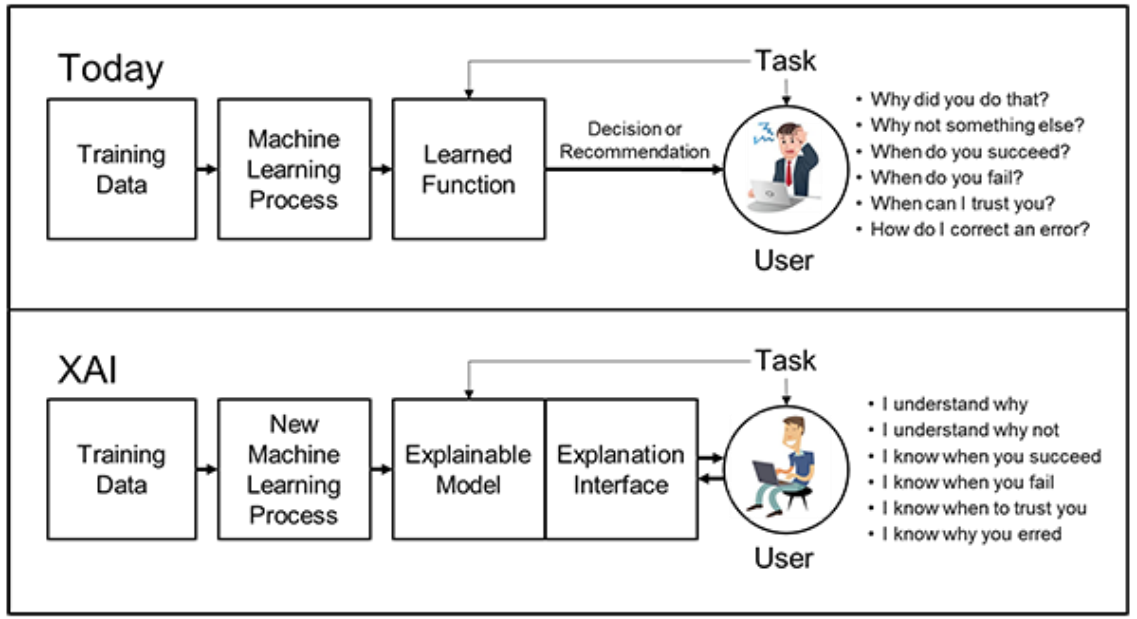
Model use

Converting Data to Decisions with Analytics

FAQ: Do users trust what analytics tells them to do?

Analytics Solution: Explainable AI

Use models, algorithms, and user interfaces designed and validated to help users understand and better trust the predictions, projections, and recommendations from analytics-based decision-support tools



Source: https://www.darpa.mil/program/explainable-artificial-intelligence

Converting Data to Decisions with Analytics

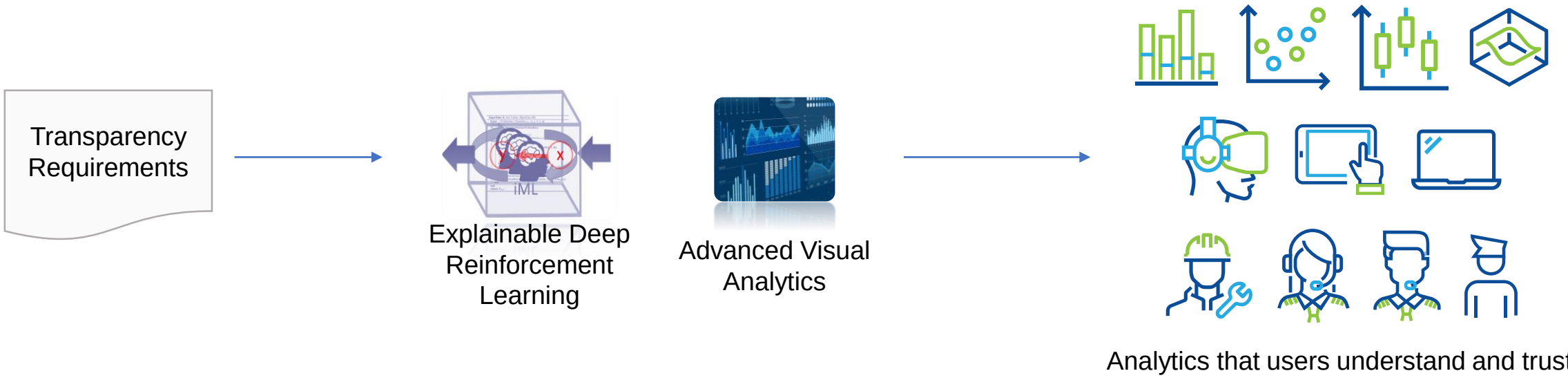
Analytics Solution: Explainable AI

One current effort is a SESAR project to investigate explainable AI for controller automation

TAPAS – Towards an Automated and explainable ATM System https://www.sesarju.eu/projects/tapas

- Multidisciplinary team of commercial system providers, universities, and research institutes
- Investigating explainable AI to enable increasing levels of automation in ATM tools

The same approach can be applied for airspace user systems and tools

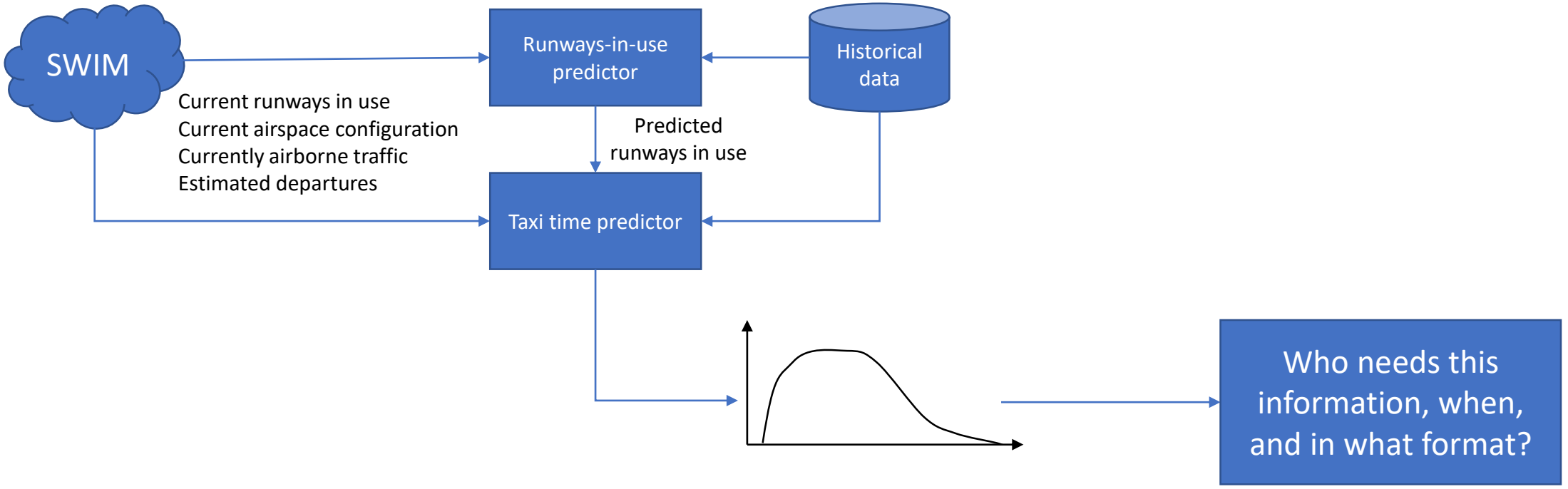


Converting Data to Decisions with Analytics

FAQ: With all that data being published, isn't the user just overwhelmed?

Analytics Solution: Show the user relevant data with recommendations, not raw data

Example: taxi-time prediction



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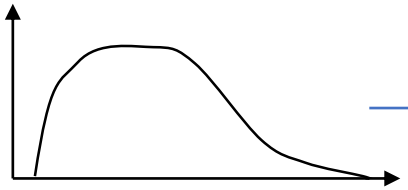
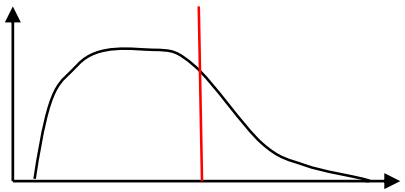


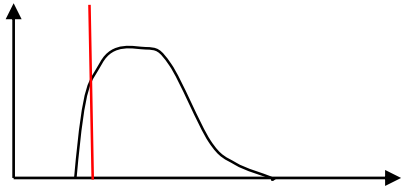
Who needs this information, when, and in what format?

Dispatcher needs to plan taxi fuel
A robust solution is at the **high** end of the taxi time distribution



ETD -2 hours

As ETD approaches, the prediction is revised with less uncertainty



Pilot using single-engine taxi needs to know when to start the second engine so it is sufficiently warmed up when they get takeoff clearance. A robust solution is at the **low** end of the taxi time distribution

Pushed back, tug disconnected

Converting Data to Decisions with Analytics

FAQ: Can the availability of real-time data make planning better?

Analytics Solution: simulate SWIM-enabled disruption recovery in robustness calculations

- Use historical data to improve models of all operational disciplines
  - Block times
  - Fuel burns
  - Disruption probabilities
  - Finer-grained robustness buffers
- Use probabilistic optimization to incorporate long-term forecasts, revising plans closer to the day of departure
- Simulate recovery techniques and technology – driven by availability of real-time data via SWIM and associated real-time analytics – to further reduce buffers

Recommendations to Data Providers

- We know ANSPs have limited budgets and bandwidth. Our priority recommendations for your investment resources:

    1. Whatever analytics help you to manage traffic (but publish them for airspace users also!)
    2. Additional raw data that only you know or have access to – things airspace users can't get from other sources – and whatever contextual data you can add to that
    3. Additional predictive or prescriptive services for airspace users are a distant third priority – airspace users and their partners can work on these as their own priority, and will use their internal data to better tailor them to their own operational needs

- Rationale for this recommendation:
    - Airspace users will do their own analytics anyway
    - When ANSPs publish predictions, airspace users will check them – they will use them as part of the picture, but they will conduct their own analyses anyway
    - Some of the relevant internal data that airspace users have isn't readily usable by ANSPs

- That said, we know predictions are valuable to ANSPs also, and we do appreciate publishing whatever predictions you make for your own use

Conclusions

- Context is essential for data to enable better decisions by individuals and teams
- Frequently-raised concerns about the value of SWIM are valid, but can be mitigated by analytics and connectivity
  - Aggregating, harmonizing, cleaning, and augmenting data
  - Selecting relevant insights for individual users and use cases
  - Distributing predictions and recommendations to actors
- More raw data – and contextual data as available – published by ANSPs will help airspace users to get the right insights to users across multiple disciplines so operations can be both more efficient and more robust